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season, but also to do our utmost in promoting geographical investigation and geographical progress of all kinds. There is plenty of work to be done. It goes without saying, however, that members and officers alike will have to give time and thought and effort if significant results of these kinds are to be reached. In my own judgment, our success will be measured chiefly by the amount of geographical activity that comes to be associated with our meetings. The reading of papers is one indication of such activity; but it is not the only one, and perhaps not the most important one.

In the midst of great diversity of interests, and of active competition with societies in other subjects, there are, on the one hand, evident difficulties before us. We hope, on the other hand, to bring prominently forward the geographical element in all our work here presented, in order to strengthen the bond that draws us together; and we must, if possible, arrange the time and place of our meetings so that the other interests of many of our members shall not suffer. The Council of the Association will ask the best suggestions of all members toward these ends.

We have one great encouragement. A year ago we were only an imaginary quantity. Now we have taken form; we have already an enviable list of members, a good programme for our first meeting, and a representative, if not a large attendance. A great opportunity for useful work is before us; we have only to press forward to reach it. Let us press forward together!

CIRQUES: A REVIEW.

BY

ROBERT MARSHALL BROWN.

Description: Cirques have been described as crescent-shaped hollows or half-cauldrons on the sides of mountains (Geikie, A., 1887, 157), as large spaces excavated from the solid rock, bounded on three sides by an almost cylindrical steep mountain wall, and with a tolerably flat floor (Helland, 1877, 161); armchair-like recesses in mountain sides (Richter, 1900, 103).

The essentials are the steep sloping sides, the embayment in a mountain slope, the exit facing the valley, with a sill generally above the level of the floor of the cirque, and the sharply-cut remnants of mountains where cirques have been numerous, shading to the more normal form of mountains in unglaciated regions where this feature has been less common. The variations of cirques

depend on the differences of rock structure as well as the accidents of the agents of modelling. The shape and size depend upon the resistancy of the rock. Every rock has its own peculiar type. Weathering may have softened the rugged outline, if the time since the last vestige of ice was melted has been sufficient. The sill may be of rock, a remnant of a less efficient erosion, or of morainal matter. The basin itself may contain a lake, if time has not been long enough to allow a complete breaching of the sill. Talus, from the cliff walls, tends to fill up the basin, and aids in its way in obliterating the lake or tarn.

Name: Custom has not yet made a decision as to the universal name of this feature of mountain sculpture. Many countries furnish their own local names, and the word has been parenthetically translated into three or four languages, when the form is mentioned —thus, corries (Cirques, Karen, Botner). In the Scottish Highlands, corry is the prevailing word; in Wales, cwm; in Norway, botn; in the Alps, kar; while the French-Swiss supply the name cirque. Cliffed amphitheatre is less commonly applied to the true cirque type. This last name is reserved for a similar form of a somewhat different origin.

Localities: Cirques have been described from nearly all mountainous countries. Those of Scotland, Norway, and the Alps have quite monopolized the attention of geologists, mainly because of their prominence, numbers, and accessibility. The Pyrenees offer good examples. The Balkan Peninsula, the Himalayas, Greenland, and our own Western mountains furnish a number of features.

Theories: A theory of the origin of cirques was early published (Forbes, 259), in which they were described as craters of upheaval. The diversity and character of the rocks in which they occur did not allow this theory to gain strength.

Bonney (1871, 320) considered them pre-glacial, and treated them as the result of streams falling over cliffs. He demanded certain favourable conditions of the ground; upland glens so shaped as to give rise to and maintain many small streams; moderately horizontal strata; strata of such a nature as will allow of the formation of cliffs, the most favourable being thick beds of limestones, with alternating bands of other rock.

A little later cirques were described in the Alps and in the Himalayas. In the latter the ice still occupied them (Drew, 1873, 399). The floor was filled with ice, and the steep sides were covered with accumulations of snow. In the Alps, Gastaldi (1873, 396) was convinced that the cirques were formerly occupied by

glaciers but little anterior to the modern period, and that the ice was well able to excavate for them deep beds in all kinds of rock.

In 1877, Helland (1877, 161), after an extensive study of the cirques of Norway, Scotland, and Greenland, stated that they were connected with glacial invasions. Furthermore, he considered that their position had some relation to the line of perpetual snow. As in Norway, cirques were found to be numerous in regions of small isolated glaciers; and as the limit of the snow is most favourable for the formation of such glaciers, the relation is a consistent one. While Helland placed the line of perpetual snow as a prominent seat of corry construction, he fairly stated that, inasmuch as it is in accord with glacial laws that glaciers flow much below the snow limit, so cirques will exist below; and, on the other hand, retreating ice will place cirques at higher levels.

A. Geikie (1887, 165) deemed that the formation of cirques was due to torrential streams, converging towards a mountain chasm. Frost was considered a powerful factor in the process, while snow and glacier ice was admitted as a not less powerful source of aid in the work.

J. Geikie (1895, 236) made a distinction between cirques of non-glacial origin and those of glacial origin. While many valleys headed in cirques before the ice invasion and in countries with no glacial record cirques appeared, they did not, however, exhibit the basin-like bottom nor cliff wall which characterizes cirques of glacial origin. He considered that many of the glacial cirques were born of non-glacial cirques. These non-glacial amphitheatres served as channels, and the ice, concentrating its erosion, scoured out a basin.

Johnson (1899, 112) explains the recession of the cirque walls by a process which he calls sapping. A glacier scours its valley downwards and outwards because of the direction of ice advance and the weight of the mass. The sapping process, on the other hand, is backward and horizontal. Where crevasses which extend to the base occur in a glacier, the rock is exposed to excessive weathering by frost agencies. The greater part of this action is probably the result of a diurnal change of temperature during certain seasons of the year. There is then a disrupting of the rocky base, a new position of crevasses posterior to the first location, and a gradual recession of the cliff walls as the process repeats itself. The glacier makes the cirque, in the first place, by this process, and then, by continual occupancy, enlarges it. The final result of the erosive action is to subdue the mountain.

Matthes (1899–1900, 173) considers a cirque as a modified pre-glacial stream-worn valley whose V-shaped cross section has been converted into a wider U-shaped one, and whose grade has been flattened rather than lowered. In order to have a typical cirque, he insists that the pre-glacial valleys must be far enough apart, so that the recession will not cause a coalescence of such valleys, that there must be no subsequent sculpturing by remnant glaciers on the crests of the mountains, that the rock be homogeneous, and that there be no post-glacial remodelling by weathering or erosion. Matthes agrees with Johnson so far as to state that the cirque is essentially the product of a crevasse, and that if it were not for the opening which allows the outside air to reach the foot of the cirque wall the latter would have no tendency to recede, and therefore, no cirque would be formed.

De Martonne (1901, 10) considered that cirques are as evident indications of glacial action as roches moutonnées and striæ.

Davis (1901, 305) connected the formation of cirques with local glaciers—the dwindling tributaries of the greater glacial streams. The sill and the basin floor are not consistent with an actively-flowing stream. While the greater part of the work of deepening and widening a cirque may be done during the tributary stage of a glacial head stream, the final touch must depend on the remnant of the stream left in the cirque. The length of time during which this local stream works will determine the completeness of the basin. That the cirque should possess a sill and a rock basin is the result of differential work of the local glacier. At the terminus of the ice stream, the disappearing ice will do little work. Back from the melting front, erosive power must increase for a time because the thickness of the ice increases. The maximum point is soon reached, and a decrease begins as one passes towards the névé fields. This position of maximum erosive power in a glacier limited to a cirque is sufficient, in time, to yield the basin. When the local glacier was a part of the larger stream—taking the condition of the cirque glacier as the remnant of a more extensive flow—the maximum would be located in respect to the entire stream, and no basin would be possible in the head branches unless resistant rocks were encountered.

River Amphitheatres and Cirques: River amphitheatres are formed as in the Colorado River, where the head waters come in in all directions, and where the action of the water on the rocks is equal on all sides. In glacial-formed cirques, the retreat of the ice over the sill has worn the bottom of the basin deeper than the outlet,

and abandoned cirques often hold lakes. River amphitheatres, on the other hand, must always be open to drainage, inasmuch as they are stream-made. In rivers, if the head of drainage is not reached, no amphitheatre will be formed; but the river will cut back, forming a cañon narrowing upwards towards the source. The conditions necessary for the formation of a river amphitheatre are numerous and fairly exact, so that such features in rivers are uncommon. Bonney's conditions of cirque-formation, above mentioned, might well find a place here. Cirques are too common a feature of mountains, and too independent of rock structure, to have been reared under such limitations.

The term valley cirque has been applied to the long glen into which the cirque proper opens. They are the result of the erosion of the trunk stream, and generally show features similar to those of the mountain basin. They represent the work of the ice previous to the more local habitations in the mountain sides.

Special Features: The interior of a cirque shows a breaking of the rock, not the smooth wearing that would be expected. The rather jagged interior suggests strong action, and is very likely associated with the temperature, which must hover about the freezing-point. The melting of the ice filling the cracks of the rock with water and a subsequent freezing would account for this. Simple water action alone could not produce such a form. In a retreating glacier occupying a cirque the alternating melting and freezing must be diurnal for a considerable season.

The outlines of most of the highest mountains are due to cirques. Richter (1900, 103) goes so far as to say that the Alps would show the rounded form of subdued mountains to-day if they had not been invaded by ice. The steep cliff-like walls of neighbouring cirques meeting in a sharp edge often yield arêtes or fish-back ridges. Three cirques coming together form a drei-kanter, as in the Matterhorn. The rounded form of Mont Blanc seems to have been singularly free from such invasion. Much of the Alpine region shows the sharply-serrate forms. This may be applied with almost equal force to Big Horn Mountains, to Norway, to Scotland, and, in fact, to all glaciated mountainous regions. It has been pointed out, moreover, that as in the Alps passing from west to east cirques occur at higher and higher levels, we may use this as evidence that the snow-line of glacial times gradually rose to higher levels as it passed from west to east into the interior.

An interesting case of glacial capture is instanced by Matthes (1900, 167–190). In the Big Horn Mountains two cirques are so

situated that one seems to overlap the other. The present drainage from one turns sharply and passes through the other. The slope of the latter is steeper than the slope of the former, and the suggestion arises that the latter encroached upon the field of the former and effected a capture of its drainage.

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WORCESTER, MASS.

A RÉSUMÉ OF THE GEOGRAPHICAL DISTRIBUTION OF THE DISCOGLOSSOID TOADS IN THE LIGHT OF ANCIENT LAND CONNECTIONS.*

BY

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The discoglossoid toads form a small, compact group of five recent genera remarkable for their primitive structure and for their extraordinarily disconnected distribution. One genus, *Liopelma*, is the only batrachian found in New Zealand. Another genus,

* A paper read before the Association of American Geographers in Philadelphia, December 29, 1904.